Nice^3 Final Report

Colorado Corn

February 28, 2004

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Section 2: Narrative

A. Brief Summary of the Original Project Goals

The concept of precision farming is to apply the right amount of inputs at the right time on the right area, conserving both water and agricultural chemicals while improving production output. Producers are interested in exploring the potential of precision farming but are confused as to the first step to take in adopting the new technologies.

The irrigation and agricultural industries have not had access to reliable technology to accomplish site-specific application of solutions on a small scale within individual pivot pipelines. In addition, there is no commercially available integrated software system for making precision farming decisions and managing small-scale site-specific application relative to specific field conditions.

Our overall goal was to develop an integrated system of precision farming tools with scientific technology enabling farmers and agricultural consultants to assess field conditions, create management zone maps, and control applications in small sections within fields irrigated with center pivot irrigation systems.

A related goal was to integrate into the system software-based data collection methods that produce GIS layers of information about variations in water, nutrients, vegetative material, and pests, enabling producers to analyze data and make better precision farming management decisions.

Our objectives were to:

1) Assess spatial variability of crop production parameters, including water, soil, nitrogen, and weeds, at the field scale using remote sensing and sensor technologies such as multi-spectral digital images and electrical conductivity, and new or refined methods of field sampling and data analysis;

2) Evaluate and develop assessment tools to determine the potential benefits to crop production, water quantity and water quality, the change in risks from modifying the amount and timing of inputs, and the costs of implementing irrigated precision agriculture systems;

3) Develop management tools that enable producers to readily implement precision agriculture technologies for spatial and temporal application of water, nutrients, and pesticides, and;

4) Evaluate and improve the performance of commercial variable rate chemical application equipment mounted on self-propelled sprinkler irrigation systems.

We proposed to use soil maps, grid soil sampling, Veris maps, yield maps, aerial imagery, and field scouting to help determine the management zones. In doing this, we were also looking for the most reliable and economic way to determine the zones using one or more of the above methods. *(See Appendix)*

2) *Frequency Analysis of Yield For Delineating Management Zones*
3) *The Value of Additional Data to Locate Potential Management Zones in Commercial Fields*
4) *Frequency Analysis For Delineating Yield Zones*
5) *Analysis of Multi Year Yield Data for Delineating Yield Response Zones*

Once the zones were established, we intended to use the Accu-Pulse system developed by Valmont Industries to variably apply fungicide, pesticide, or fertilizer to the different management zones as needed. *(See Appendix)*

6) *Accu-Pulse Theory of Operation*
7) *NDSU and University of Arkansas Studies*

Ultimately, our goal was for the technologies demonstrated and commercially validated through this project to help agricultural producers to save energy, reduce waste, and remain economically competitive as they target and meet the needs of new industrial markets.

B. Variance from Project Goals

The first three objectives have been to a large extent met within the scope of our project.

The last objective included the commercialization of the Accu-Pulse chemical application system for variable rate application of chemicals. The agricultural economy has had a downturn and the marketability of the Accu-Pulse system has not progressed as anticipated. This has delayed the full development of the system to add the capability to apply chemicals at a variable rate in a commercial sized field. Research is continuing in this area but the immediate availability of commercial equipment may not be realized.

A detailed field plan was developed to demonstrate the temporal distribution of irrigation water and nitrogen application, but this was abandoned due to the extreme drought. The cooperating farmer was unable to secure water rights to continue irrigation during the 2003 irrigation season. This was a severe setback not anticipated in the development of the project, as this is the first time in history that the fields did not have rights to water for irrigation.

C. Demonstration Results

The overall project goals were to reduce energy consumption and commercialize the Accu-Pulse chemical application system. The Accu-Pulse system saves energy by the low power requirement to apply chemical to the entire circular irrigated field. A secondary benefit is the ability to variably apply chemicals on the field and reduce the amount of chemical input for pest control and fertility management. Any reduction in chemical use also has an energy saving

component for the manufacture and delivery of the chemical product. The ability to commercialize the system also recognizes the need for improved management of the entire farming system. Servi-Tech had the main goal of providing consulting services to recommend proper timing and amounts of fertilizer.

The two test sites were sampled on a 2.5 acre grid for mapping the soil parameters and nutrient requirements. For each site, a total of 52 soil samples were collected and analyzed for the following parameters; pH, organic matter, soluble salts, Nitrate nitrogen, phosphorous, potassium, sulfur, zinc. Maps of these data were used to draw management zones where different amounts of fertilizers were recommended. The results demonstrated that it is feasible to develop maps of the requirements for variable inputs. Water well samples were collected and analyzed for nitrogen, chloride, sulfate, sulfate-sulfur, carbonate, calcium, magnesium, sodium, potassium, boron, electrical conductivity and pH. These data aided in making management recommendations.

Scouting site visits were made weekly during the growing season. Recommendations were provided to the producer on irrigation, fertility and pest management.

Y-W Well Testing also provided weekly scouting to the two fields. Eight and four sites were instrumented at the Yuma and Wiggins sites, respectively. At each of the sites, soil samples were collected and analyzed for nitrogen content for use in recommending fertilizer application amounts. Gypsum blocks were installed at the 6, 12, 24, 36 and 48 inch depths and read weekly to track the available soil water in the top 4 feet. Seasonal tables and graphs were developed and provided to the grower. The data revealed that the producers were applying sufficient water to meet crop demands during most of the season.

We found that simple redesign of the sprinkler irrigation systems reduced the necessary amount of water application significantly. Improvement of the uniformity coefficient from 86 percent to 96 percent reduced the amount of over-irrigation necessary to adequately irrigate areas receiving the least amounts from an estimated 25 percent to 5 percent. The gross irrigation requirement was reduced from about 25 inches to 21 inches, with a commensurate reduction in energy consumption. In addition, the amount of nitrogen fertilizer required to be applied through the irrigation system to avoid nitrogen stress to the crop was reduced correspondingly.

We developed a new lifting system for the AccuPulse technology to allow the accumulators to be lifted higher, eliminating any potential water pattern interference. Valmont also redesigned the accumulator and obtained a new fabricator with higher quality control standards. The resulting product delivered a much more uniform volume of chemical solution.

During the non-growing season, the Natural Resource Conservation Service technicians dug pits in each of the field sites. Pits were dug three times during the project. They observed soil compaction in each of the sites and recommended changes in tillage practices. The sites were significantly different in the available water holding capacity (AWC). The Wiggins site was estimated to hold 1.5 inches of AWC in the top 24 inches as compared to 4.9 inches AWC in the top 24 inches at the Yuma site. These differences obviously influence the irrigation capacity and scheduling criteria for maximum yields. The data and reports are all included in the appendix.

Y-W Well also performed eleven pumping plant tests at each of the fields. The average wire to water efficiency was equal to approximately 60% for both fields. This is a reasonable good efficiency. For each of the tests a spread-sheet was run with various assumptions and the resulting energy that could possibly be attained for both fields. It was unfortunate that the water pumping level could not be measured at the Yuma and an assumed pumping depth of 272 feet was assumed for all tests. This would make questionable any of the assumed energy savings. At Wiggins the pumping level varied from 80 to 90 feet with the maximum pumping depth to occur during the peak water use period of the crop. The examples assumed some energy savings for improved water management. Experience in Eastern Colorado indicates that a large portion of the savings could be associated with the proper scheduling of irrigations. Wiggins resulted with some over irrigation but this is often expected with the low water holding capacity and the irrigation frequency of the producer. Yuma with higher water holding capacity is easier to manage without over-irrigating.

The data from both Servi-Tech Laboratories and Y-W Well Testing Association demonstrate the potential for improved management and variable rate application of inputs that would save energy with the commercialization of the Accu-Pulse system. The unfortunate situation is that the current economics and market for the variable rate application tool does not pay the cost for commercialization at the current time. The data collected and the demonstration of the tool clearly met the project objective of justifying the use of the Accu-Pulse system to save energy should the economic conditions be favorable for adoption. *(see appendix)*

8) Servi-Tech data
9) Y-W Well data

Additionally, we developed a website http://coloradocorn.com/precisionirrigation , printed 10,000 brochures, and created a Power Point Presentation for a multimedia kiosk about the project. All products describe the project, highlight irrigation and application challenges, and discuss the benefits of precision farming technologies. *(see appendix)*

10) Front Page of Website
11) Brochure
12) Kiosk Material on CD

We also successfully demonstrated the Veris EC system for mapping the electrical conductivity (EC) for large-scale fields. The results have shown significant progress in identifying management zones for the application of variable rates of fertilizers and pesticides. The monitoring of applied water with comparisons of actual water requirements has led to farmers improving their temporal management

Results did demonstrate the potential of real time application of nitrogen based on remote sensing of the growing corn and its need for nitrogen. Historical low and high yielding areas within the demonstration sites were soil sampled to determine NO_3-N levels before and after the growing season to evaluate effectiveness of in-season N management based on remotely sensed crop N assessment. Residual NO_3-N in the crop root zone was reduced by 117 lb/ac in the high yielding area and remained at similar levels for the low yielding area. In-season N application

was reduced based on crop "need" while not reducing grain yield, and crop root zone soil NO_3-N levels were reduced which minimizes potential N leaching and degradation of the environment. *(See appendix)*

13) *Practical Utility of Bulk Soil Electrical Conductivity Mapping*
14) *Temporal Stability of Soil Electrical Conductivity in Irrigated Sandy Fields in Colorado, including summary of statistics for each location*
15) *Field Mapping: A New Tool to Make Better Decisions*
16) *Electrical Conductivity Spots Salty Soils*

Many high value crops are treated multiple times with fungicides applied either by air or chemigation in order to maintain disease control. A comparison of the efficiency of Accu-Pulse versus chemigation for applying chlorothalonil, a widely used fungicide, on potatoes showed that there was 10 fold more residue of chlorothalonil on foliage treated with Accu-Pulse compared to chemigation, and the concentration of fungicide remaining on the leaves 7 days after application was greater on plants treated with Accu-Pulse than on leaves 1 day after treatment with chemigation. These results suggest that farmers could reduce the number of applications of fungicides utilizing Accu-Pulse and still maintain efficacy.

The Accu-Pulse system has been tested in the laboratory for uniformity of chemical application in conjunction with field tests. The conclusion is that the system has significant scientific and commercial benefits. The major problem facing the implementation is the high cost of the system and the poor agricultural economy. The work will continue to develop other applications of the system that will enhance the economic benefit of variable application during the growing season to provide a cost effective system. *(see appendix)*

17) *Comparison of Accu-Pulse, a New Spray System for Irrigated Agriculture, with Ground Rig and Aerial Application of Pesticides.*
18) *Comparison of Accu-Pulse, a New Spray System for Irrigated Agriculture, with Cemigation.*
19) *Instructions for installing and running Accu-Pulse Variable Application Software and Installation CD and screen shots*

Continued research will strive for evaluating multiple economic benefits of variable application of chemicals during the growing season. A combination of these benefits may lead to the economic viability of the Accu-Pulse system that could be put back on the market when farmers are able to afford the cost and increase their profits with adding the new tool to their battery of tools in production agriculture.